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2. Patent application number *(The Patent Office will fill in this part)* — 0325658.3 — 04 NOV 2003

3. Full name, address and postcode of the or of each applicant *(underline all surnames)* — DE-BONDING LIMITED, 16, Dumaresq St, St Helier, JERSEY, Channel Isalands, JE4 8SU

   Patents ADP number *(if you know it)* — 8601940001

   If the applicant is a corporate body, give the country/state of its incorporation — United Kingdom

4. Title of the invention — Method and Apparatus for Bonding and Debonding Adhesive Interface Surfaces

5. Name of your agent *(If you have one)* — Harrison Goddard Foote

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* — Belgrave Hall, Belgrave Street, Leeds, LS2 8DD

   Patents ADP number *(if you know it)* — ~~14571001~~ 7631310002

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Signature: Harrison Goddard Foote

Date: 4 November 2003

12. Name and daytime telephone number of person to contact in the United Kingdom: Dr Lisa Brown 0113 233 0100

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P101655gb.3-11-03

Method and Apparatus for Bonding and Debonding Adhesive Interface Surfaces

The present invention relates to a system and a method of attaching or bonding two or more surfaces together and a method of detaching or debonding them and an apparatus therefor. The method and apparatus of the invention is of particular, but not exclusive use, in the automotive, aeronautical, nautical, decorating, packaging and construction industries for adhesive bonding and debonding of panels, frames, films, joints, plates, glazing or any other such items which need to be bonded together and/or separated. The system of the present invention may also be used as a vehicle or transporter for other agents and to aid in their dispersion within a matrix.

Background to the Invention

It is known from the prior art to attach car body parts together, by for example, riveting or spot welding them together and more recently laser. A recent trend in the car industry is to use a modular construction for vehicles, whereby individual modules are connected/attached/bonded to form the main vehicle body and associated parts. Typically car door or body panels are welded and/or riveted together in order to achieve a tight attachment of the two parts. Welding uses intense heat to melt one or more of the interfaces of the parts and needs to be performed by specialists aware of the risks of intense heat, both to themselves and to car parts. The intense heat can cause the substrate surface to buckle or melt and great skill is required to ensure that only the sections/portions/spots needing to be welded actually receive the heat so as to minimise the potential for heat damage to other parts. In order to detach these riveted/welded parts strong mechanical strength is required.

It is also known in the prior art to use adhesive compositions to effect secure attachment of two surfaces/substrates of vehicle components. Adhesive compositions or glues have been widely used to secure windscreens to frames by applying the adhesive to one or both surfaces of the components and aligning them so that the

surfaces are bonded/attached together. Typically the adhesive compositions contain curing agents in order to promote or accelerate the adhesive solidification process. The curing agents can be heat or moisture activated and are included in the composition so as to cross-link or polymerise the liquid adhesive into solid form and so accelerate the chemical bonding process. In order to detach the adhesive bonded component(s) thermo-mechanical strength can be applied to separate them. For example, in the instance of detaching a windscreen from a frame which has been firmly bonded in place as the adhesive sealant is hardened, typically involves the automotive glass fitter to remove the windscreen (usually in intact form) using a device comprising a cheese-wire or special knives to cut/saw through the hardened rubber along the periphery of the windscreen. This process requires strong physical force to separate structurally the cohesion strength of adhesive and can lead to musculo-skeletal conditions in the fitters themselves as a result of repetitive strain injury. Further problems associated with this method are that the cheese-wires can overheat due to friction, additionally the wires themselves can break. It is becoming routine in the automotive industry in an effort to minimise vehicle weight to improve performance and reduce petrol consumption to use adhesives to bond other car components such as door skins to frames, accordingly the use of adhesive compositions is becoming more widespread in this area of technology.

Thermally expandable thermoplastic microspheres have been commercially produced for several years and have been used as fillers in polymers, paints, putty, plastisols, printing inks and as fillers in paper, paperboard and explosives. WO 95/24441 describes a substitute to polyurethane foams in the form of an adhesive composition for filling vehicle box parts and providing sound-proofing which includes 5-15% of expandable micro-spheres encapsulating alkanes. WO 00/75254 also describes adhesive compositions comprising thermo-expandable microspheres, heat activation of the microcapsules creates a pressure along the interfaces of where the composition has been applied which reduces the structural cohesion and shear or tear stress of the adhesive material. The reduction in chemical and/or physical bonding of the adhesion at the interface of the two bonded surfaces is due to the effect of the

expanded microspheres so that they may be described as capable of de-bonding with no cohesive fracture when in their expanded state.

One of the problems associated with the automotive industry is that at the vehicle end of life most of the vehicle components more than 85% have to be detached and removed from the vehicle so that they can be safely disposed of or recycled in separate and dedicated processes. The disposal of vehicles at the end of life can be time consuming and expensive as interior items, dashboards, panels, door skins, plates, frames, light units and other such components need to be detached from one another.

A method and apparatus to carry out a method which would enable rapid, ideally in a matter of minutes, efficient and safe detachment of such components would offer immediate advantage to the prior art, not only in the automotive industry but in any field where it is desired to detach two surfaces/substrates that have been bonded together by means of an adhesive.

Statement of the Invention

According to a first aspect of the invention there is provided an adhesive system comprising curing and/or de-bonding an adhesive composition, the composition being placed between two or more surfaces of supports or layers, and the adhesive composition comprising an adhesive and dispersed therein thermo-expandable microspheres the system comprising the steps of:

activating a method of curing the composition by providing a first level of thermal radiation and/ or thermal conduction and/or thermal energy which passes through the adhesive composition so the contents of the expanded microspheres leach or migrate through their porous shells;

de-bonding adhesive interfaces of the same surfaces of supports or layers by providing a second level of thermal radiation and/ or thermal conduction and/or thermal energy which passes through the adhesive composition so as to expand the microspheres.

The method comprises two distinct phases or stages which in practice are performed at two different time points and typically may be performed days, weeks, months or years apart.

The first phase or stage is curing. Curing is generated by a first species of thermally expandable microspheres dispersed in the adhesive bead matrix. This first species encapsulates within their plastic or copolymer shell a blowing agent and curing agent preferably mixed together. The curing agent disperses in the adhesive matrix when sufficient thermal radiation and/ or thermal conduction and/or thermal energy and or electrical energy is supplied to this first species so as to cause thermal expansion and allow their contents to leach or migrate or pass or be transferred or be released through or across the porosity of the expanded shell. The contents of this first species of thermally expandable microspheres is released into the adhesive matrix at a certain specified temperature which is necessarily lower than that of the second species of thermally expandable microspheres which are employed to effect debonding. The second species of microspheres, i.e. those which are activated at an elevated temperature to those of the first species are preferably provided substantially as a blend only in the interface of adhesives to facilitate separation of the surfaces.

The present invention resides in providing energy in the form of radiation and/ or thermal conduction and/or electrical heating to the microspheres of both phases of the method. The thermal conduction and electrical heating to the microspheres are via contact with surface of the substrate or by electrical current or heat through the adhesive composites. It will be appreciated that microwaves, X rays or supersonic waves may also be employed as a thermal source.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

In the present specification, bonding refers to the chemical process of adhesion during the curing process and particularly this chemical bonding in the present specification is increased by creating an increased rough or uneven surface on the area of interface especially by the thermoexpandable microspheres of the debonding phase or stage at their initial state.

The debonding microspheres are suspended in the composition floating on the uppermost surface and with a suitable size they purposefully create a rough or uneven increased surface providing higher mechanical and stress strength compared with that without microspheres.

Debonding refers to the breaking of the chemical bonding forces at interfaces. Expansion of the microspheres on the interface surface increases their volume so that the microspheres fill the entire surface space and substantially fill or occupy the whole interface surface, thus allows for the breaking of bonding forces.

In the present specification, the curing process refers to a process separate and distinct from the bonding and debonding process hereinbefore described. The purpose of the curing process is mainly to impart mechanical structural strength to the adhesive composition and chemical bonding at interface, it does not effect the volume of the adhesive bead rather it effects the mechanical behaviour of the bead rather it affects main the chemical bonding at interface.

Preferably, inside the encapsulating shell of the first species of microspheres, the curing activator may be mixed with blowing liquid which when activated by thermal energy passes through the porous shell of the expanded microspheres supported by the expanding gas.

Preferably, the expanding agent is selected from the group comprising an expandable gas, a volatile agent, a sublimation agent, water or an explosive agent.

Preferably, the adhesive is polyurethane or polyvinylchloride or an MS polymer or an epoxy resin or any other suitable adhesive in which microspheres may be dispersed.

Preferably the microspheres encapsulating the curing agent or the first species of microspheres are activated at a temperature difference of between 10 to 80 C.

Preferably, the debonding or second species of microspheres are activated in a temperature range of about 50 to 200 C.

It will be appreciated that a sufficient temperature difference is required so that the two processes may be achieved without overlap and thus distinct temperature ranges are preferred. It will also be appreciated that the composition may also comprise thermoexpandable microspheres encapsulating more that one different or combinations of agent and that each set or species of microspheres may differentially be expanded when exposed to suitable temperatures so that the composition may go through a set of defined processes according to the applied temperature which can be specified. Accordingly the method of the present invention is equally applicable to sticking and un-sticking, for example, wall paper which will require a low thermal activation or to bonding and de-bonding vehicle parts which will require relatively higher thermal activation.

Preferably, the ratio of the proportion of the first species of microspheres encapsulating the curing or other agent to those of the second species encapsulating the debonding agent will be variable and it will be appreciated that the proportion may be selected according to a user's requirements or for the particular application.

Preferably, the first and/or second species of microspheres may be coated in a suitable black or dark material to increase optical density and thus prevent UV light penetration. In one example when the method and composition is for use with vehicle glazing, the frit can be coated with microspheres coated with a dark material with a purpose to further reduce penetration of UV light and to reduce degradation.

It will be appreciated that by coating the microspheres with a black material this acts to reduce the optical density of the frit on the windscreen or, if desired, stereographical printing. We have found that it is necessary to coat the microsphere in the appropriate material as the coating affects their porosity. Thus when the microspheres expand, the porosity of the frit is affected and in practice, this creates a barrier to the UV.

In this embodiment of the invention, that is to say coating of the microspheres with additional agents, the unexpanded microspheres may be coated with agents depending on the user's requirements. For example the unexpanded microspheres may be coated with, for example and without limitation:

- a monomer to be catalysed by UV radiation or other energies for improved adhesion in a polymer matrix

- nanoparticles to improve their distribution and/or their dispersment.

- molecules which create barriers to, for example, electromagnetic waves, chemicals like O_2, acoustic and sound waves, thermal or any other function for which it is desired to create a barrier.

These functions operate on the expanded surface which can realise up to $10m^2$ for only 1 gram of microspheres present in the matrix. It is believed that the present invention may be used to improve the dispersment of, for example and without limitation, scent, fragrances and/or cleaning agents into a solvent such as water. It may also be used to improve the delivery of pharmaceuticals and other such agents. It may also be used as a barrier to prevent clustering of nanoparticles and such like.

In one embodiment of the invention, the microspheres can be coated with suitable molecules on their surface so that the microspheres act as a "vehicle" or "transporter" to enhance the effect of the carried molecule, and in so doing the microspheres may

improve efficiency and dispersion of the carried molecules. It is envisaged that the microspheres may, in this embodiment, be used following the principles as set forth:

- the microspheres may be used as a vehicle for dispersing a carried molecule in its coating to a larger molecule.

- the microspheres may act as a chemical or physical barrier.

- the microspheres prepare molecules to be evenly, easily and more readily dispersed.

- the microspheres can act as a support where a photocatalysis is efficient as the molecule acts as a very thin film on the expanded microsphere surface.

In summary, the microspheres can be coated with various materials making them multifunotional and useful for addressing many problems and many different areas of use. As previously stated the microspheres can be coated with either a monomer and/or nanoparticles these entities can be distributed on the surface of the microspheres in their unexpanded state and they can have multifunctions. We have utilised the change in volume of the microspheres so that their surface becomes up to ten times more than their initial surface so one can achieve , from a single gram of microsphere in the matrix about 0.5 m^2 and if we use microspheres of a different expansion capacity for example of up to 100 times the volume expanding we can achieve between 6 to 10 m^2 of surface. In such an embodiment, the microspheres can be used to disperse the parts of the materials i.e. monomer and/or nanoparticles that are on their surface.

In this sense the microspheres act as a vehicle to make the coated particles ready to be dispersed in the salvage state in order to reduce the time of their dispersion. Accordingly it is possible to achieve a surface that will attain the same longevity with

the same particles because the shell reduces thickness but the materials that are on the surface of the expanded microspheres remain the same.

The microspheres may also be used according to a second critical observation in that they tend to become a barrier for electromagnetic radiation and also a barrier to acoustic waves passing through such a matrix containing them.

The microspheres may also be used to prevent clustering, that is to say clumping together of molecules a problem associated with the cleaning industry.

Preferably, the thermal radiation and/ or thermal conduction or electrical energy provided to the microspheres is provided from a means comprising a source of electromagnetic waves such as IR or UV radiation, or from a convection oven or from electrical means such as a battery or a laser or from an ultrasonic source or from gas or air or from white light.

As will be appreciated IR is an electromagnetic wave which only becomes thermal when it is absorbed by a body with certain properties onto which the IR is directed. Thus a system employing IR only becomes a "thermal" system when the IR beam is absorbed by the body. Accordingly IR radiation becomes a heating source by changing the IR electromagnetic waves of 800-2600 nm up to thermal radiation 3000-7000 nm and thermal conduction. In the present invention the thermoexpandable microspheres are principally heated by IR and/or thermal radiation and not thermal conduction from the panel.

In the instance of using IR radiation spectrum as the energy source, it will be provided in the form of one or more lamps or in the form of optical fibres or optical rods or plates. IR radiation will be transformed to thermal radiation of the internal surface, of for example a panel, on the heating side which strongly depends on the temperature achieved by the panel exposed surface. The power thermal radiation depends on the T exp 4 of the surface panels which is not within the low range of IR

radiation as the lamp, but with thermal IR radiation of about 3000-7000 nm. It will be appreciated that heating by conduction depends on many parameters such as the thermal conductivity of the material of the surfaces or panels, the cleaner-primer and the composition of adhesives layer.

In the instance of using an electrical heating as the heating source to expand the microspheres, the electrical heating can be generated by electrical current passing through a panel which becomes a resistor. In one embodiment of the invention, aluminium or steel wires/filaments/strands or micro-wires are embedded in the adhesive composition especially at the adhesive interface so as to create a Faraday cage. The micro-wires are dispersed in the adhesive to create a tangle or polygonal arrangement of electrical conductors. This tangle allows a great number of small electrical rings to be formed in three dimensions all around the expandable microspheres which can be caused to expand at a certain maximum temperature. This phenomenon is referred to as tunnelling for electrical current.

Preferably, the micro-wire or fibres are mixed with the adhesive and may be around 100 μm in length and between 2-20 μm in diameter. We believe that in order to effect tunnelling the composition should ideally comprise about 0.5-10% volume of the micro-wires and more preferably about 1-3% volume. It will be appreciated that the volume % of microspheres within the composition affects the number of contacts bridging one with another and that this may be selected according to a user's requirements.

Preferably, the thermoexpandable microspheres may be provided embedded or coated on to a tape or mesh or film or may be provided attached to a wire or filament or fibre alternatively they may be attached to a contact surface of one or both component which it is desired to cure and/or separate. The first species of microspheres may be provided on the internal volume of adhesive materials in addition to the second species of microspheres of the de-bonding system at the interface.

Preferably, the adhesive interface comprising the microspheres of the second system may be provided in a predefined path or channel or groove or line or concentric circles provided substantially around the periphery of one or both of the contact surfaces of the items which it is desired to de-bond. In another embodiment of the invention they may be provided as a plurality of discrete spots or strips suitably lubricated at interfaces.

Preferably, the depth and breadth or thickness and wideness of the adhesive composition may be uniform or may vary as required in areas of for example a door panel requiring a stronger bond in a specific area.

It will be appreciated that provision of the adhesive in a continuous path or spot form and at differing thickness and width advantageously requires less usage and wastage of adhesive materials.

According to a second aspect of the invention there is provided a method of attaching or bonding two or more surfaces together comprising:

(i) applying an adhesive composition as hereinbefore described to one or more contact surfaces of each or all items which are to be bonded together; and

(ii) supplying sufficient thermal radiation and/ or thermal conduction to the composition via contact with one or more contact surfaces of each item which is to be bonded together so as to cause a proportion of the thermoexpandable microspheres to expand and optionally to further release a curing agent into the composition.

The present invention differs from the prior art in that the adhesive composition comprising thermo-expandable microspheres of the first system is not directly heated rather they receive energy in the form of thermal radiation from an IR source and/or thermal conduction from the surface of the item which is to be bonded.

Accordingly the present invention provides a unique approach to prior art methods of plastic-plastic, plastic-metal, metal-metal, ceramic-metal, aluminium-aluminium, aluminium-plastic and the like surface attachments since the composition is not directly targeted by for example an IR beam transparent to one of the sandwich panel but rather the composition is heated by thermal radiation and/or thermal conduction of the contact surface or its under-surface.

Preferably, the method includes any one or more of the features hereinbefore described.

We found by experimentation that the IR lamp (refection, power and source of electricity of the ray's beam) in order to be absorbed by the blowing agent and its mixture, has to be adapted to be suitable for expanding the microsphere before the degradation of the matrix embedding the microsphere.

According to a further aspect of the invention there is provided a method of detaching two surfaces that have been bonded together comprising, supplying sufficient thermal radiation and/ or thermal conduction to a surface having coated thereon or attached thereto the composition as hereinbefore described, the thermal energy being supplied to one or both contact surfaces of each item which are to be detached/separated so as to cause a proportion of the thermoexpandable microspheres to release an expanding agent into the composition.

Preferably, the method includes any one or more of the features hereinbefore described.

It will be apparent that in the present invention, chemical interactions are avoided and that the method of the present invention relies on physical engineering technology to permit and facilitate a curing system which needs to mix the curing activator by a uniform distribution at certain time at command. in the adhesive bonding stage process and advantageously may also differentiate zones where the

thermoexpandable microspheres can be suitably mixed. In principle the thermoexpandable microspheres act as microscopic containers of the curing activators which are neutral or inert up to a certain moment when they break or increase their volume in such a way to initiate their shell as a porous wall to leach the activator, in gas or liquid state, so that it can diffuse uniformly in to the adhesive matrix transport by the gas of blowing agent.

Activation of different activators is possible by the differentiation of temperature activation for the thermoexpandable microspheres, in this way it is possible to effect curing of the adhesive composition at different stages in the process at different areas and moreover at applied and specific commands making the overall process more controllable and with multifunctional performances.

The present invention advantageously provides a curing process that is controllable in that it is not dependent on a chemical reaction such as polymerisation, cross-linking, crystallisation, gelification or any other phase transitions.

According to a yet further aspect of the invention there is provided an apparatus for attaching or detaching two surfaces that have been bonded together comprising an IR emitting device comprising at least one bulb, at least one lens to concentrate the beam at certain area and at least one reflecting mirror mutually arranged so that heat is directed or focused only at an adhesive interface or a path where the thermoexpandable microspheres are purposely present.

In one embodiment of the invention the IR emitting device is in the form of one or more lamps and typically is in the form of a group or plurality of lamps.

Preferably, the IR device emits IR radiation in the range of about 800-1400 nm to 2000-6000 nm.

Preferably, the device is automated and may be linked to a computer programme providing information to device sensors of an adhesive bonding path.

Preferably, the device is mounted on a mobile unit so that it is free to follow a predefined adhesive bonding path.

The arrangement of the device of the present invention allows the IR beam to be concentrated only at certain partial points of the surface which it is desired to bond or de-bond.

Preferably, lenses with parallel shape of the adhesive-thermoexpandable microsphere bonded paths can be used with standard IR lamps where the beam can be concentrated in a special area. In this heating concept the IR optical fibre or optical tubes, even with the laser source, can be used as a flexible or rigid heating tool producing strong and rapid power by rapidly moving along the bonded area with special designed drawings of adhesive parts.

Preferably, the device may be pre-programmed to follow a specific bonding path.

The invention will now be described by way of example only with reference to the following Figures wherein:

Figure 1A shows an electron microscope picture of an upper surface of an interface to be bonded;

Figure 1B shows an electron microscope picture of a tangle of micro-wires and thermoexpandable microspheres;

Figure 1C shows a higher power view of Figure 1 B and a micro-wires;

Figure 1 D shows an alternative view of Figure 1 C and a micro-wire;

Figure 2 shows a schematic plan view of a microcapsule and film arrangement; and

Figure 3 shows a front perspective view of a vehicle door frame and skin with a conductive pathway *in situ*.

Detailed Description of the Invention

With reference to Figure 1A there is shown an electron microscope picture of the surface of an interface coated with the composition and microspheres according to the present invention. Microspheres 1 can be seen projecting above the surface thus providing an uneven or rough surface. There are gaps between the microspheres. However these gaps or voids are filled once the microspheres have been expanded so that the surface will become more even and thus be able to be debonded. In Figure 1 B there is shown an electron microscope picture of a tangle of micro-wires and inter-dispersed microspheres are also visible. As described earlier aluminium or steel wires/filaments/strands or micro-wires are embedded in the adhesive composition especially at the adhesive interface so as to create a Faraday cage. The micro-wires are dispersed in the adhesive to create a tangle of electrical conductors. This tangle allows a great number of small electrical rings to be formed in three dimensions all around the microspheres which can be caused to expand at a maximum temperature. Figures 1C and 1D are electron microscope figures at higher powers of magnification.

In one embodiment of the invention, the microspheres (1) and micro-wires (2) can be attached to a continuous conductive filament or film or wire or fibre (4). Energy is supplied to the conductive filament (2) from an energy source (3), the energy source may be provided in the form of thermal energy or electrical power and transmitted to the microcapsules by thermal radiation and/or thermal conduction. Thus the microcapsule do not receive energy directly from the energy source but rather via the panel or component surface which is to be bonded, for example the microspheres may be heated by thermal radiation and/or thermal conduction of the

panel, directly targeted by an IR radiation lamp focused on the open/exposed surface. In a yet further embodiment of the invention microcapsules (1) may be coated on to a mesh or bundle of conductive filaments/wires/fires or coated on to a tape or woven material. The microspheres (1) may be provided in a prearranged form or may be sprayed or painted on shortly before use. Once sufficient thermal radiation and/or conduction is imparted to the microspheres they may be activated at a selected temperature so as to release their contents which may be a curing agent so as to accelerate and/or effect attachment. Alternatively, the microcapsules of the second system in the instance of two surfaces having already been attached together may be made to release their contents at a different selected temperature and release an expanding agent such as a gas, an agent capable of sublimation, water, an explosive agent or an activator agent. The resultant expansion causing a de-bonding of the two attached surfaces.

In the instance of attaching a vehicle door skin (B) to a frame (A) as in Figure 3, the microspheres may be provided in pre-defined paths along the perimeter of the article which it is desired to attach. Path (5) may be in the form of a channel or groove into which the adhesive composition may be poured/sprayed or the microspheres may be provided already attached in the form of a mesh or tape or strip which can be appropriately positioned on either or both of the skin (B) or frame (A). The door frame (A) and/or skin (B) is provided with a plurality of conductive attachment means (6) and (7) respectively which can be connected to an energy source. Once the energy source is activated and the microspheres receive sufficient thermal radiation and/or conduction for example from an IR lamp of the present invention, they may expand and release their contents to effect attachment at a selected temperature or to cause de-bonding at a different selected temperature. In this way and conveniently, adhesion of two surfaces and separation of same may be achieved without recourse to chemical or physical processes using the same system and apparatus. Moreover and advantageously the system is controllable since the microspheres in the adhesive composition will be selected according to the user's requirements.

It will be appreciated that the invention has wide application to may different fields of technology where it is required to attach and detach two surfaces together for example and without limitations surfaces such as plastics, metal, ceramic, fibreglass and/or composites thereof, and that the examples in the present specification are not intended to limit the scope of the application.

Claims

1. An adhesive system comprising curing and/or de-bonding an adhesive composition, the composition being placed between two or more surfaces of supports or layers, and the adhesive composition comprising an adhesive and dispersed therein thermo-expandable microspheres the system comprising the steps of:

activating a method of curing the composition by providing a first level of thermal radiation and/ or thermal conduction and/or thermal energy which passes through the adhesive composition so the contents of the expanded microspheres leach or migrate through their porous shells;

de-bonding adhesive interfaces of the same surfaces of supports or layers by providing a second level of thermal radiation and/ or thermal conduction and/or thermal energy which passes through the adhesive composition so as to expand the microspheres.

2. A system according to claim 1 wherein the microspheres comprise a co-polymeric shell which encapsulates the curing agent or expanding agent.

3. A system according to either claim 1 or 2 wherein the expanding agent is selected from the group comprising an expandable gas, a volatile agent, a sublimation agent, water or an explosive agent.

4. A system according to any preceding claim wherein the microspheres encapsulating the curing agent have a smaller cross sectional diameter than those encapsulating the expanding agent.

5. A system according to any preceding claim further comprising a curing activator.

6. A system according to any preceding claim wherein the adhesive is polyurethane or polyvinylchloride or an MS polymer or an epoxy resin.

7. A system according to any preceding claim wherein the microspheres are activated in a temperature range of about 80 to 200 C for the debonding phase or stage.

8. A system according to any preceding claim wherein the proportion of microspheres encapsulating the curing agent are activated at a temperature difference of between 10 to 80 C.

9. A system according to any preceding claim wherein the ratio of the proportion of the microspheres encapsulating the curing to those encapsulating the expanding agent is in the region of 1:1 up to 1:100.

10. A system according to any preceding claim wherein the thermal radiation and/ or thermal conduction provided to the microspheres is provided by a means comprising a source of IR or UV electromagnetic radiation, or from a convection oven or from electrical means, a battery or a laser or from an ultrasonic source or from gas or from white light or microwaves or X-ray or sonic waves.

11. A system according to claim 10 wherein in the instance of using IR radiation it is provided as a wavelength of about 800-1400 nm to 2000-6000 nm.

12. A system according to any preceding claim wherein the thermoexpandable microspheres are provided embedded in or coated on to a tape or mesh or film or attached to a wire or filament or fibre.

13. A system according to any preceding claim wherein the microspheres are coated in a black material.

14. A system according to any of claims 1 to 11 wherein the microspheres are coated with a monomer and/or nanoparticles.

15. A system according to any preceding claim wherein the microspheres act as a vehicle or transporter or barrier or dispersing aid or aid to prevent clustering.

16. A system according to any preceding claim wherein the microspheres are dispersed in an arrangement of micro-wires so as to form a polygonal arrangement.

17. A system according to claim 16 wherein the micro-wires are about 100-200μ in length.

18. A system according to either claim 16 or 17 wherein the micro-wires are about 2-20μ in diameter.

19. A system according to any one of claims 16 to 18 wherein the composition comprises about 1-10% volume of micro-wires.

20. A system according to any preceding claim wherein the thermoexpandable microspheres are attached to a contact surface of one or more of the components which it is desired to attach and/or separate or on an internal surface of the components or at an interface of said components.

21. A system according to any preceding claim wherein the adhesive composition comprising the microspheres is provided in a continuous or discontinuous predefined or in spots in path or channel or groove or line or concentric circles provided substantially around the periphery of one or both of the contact surfaces of the items which it is desired to attach or detach.

22. A system according to any preceding claim wherein the depth and breadth or thickness and wideness of the adhesive composition may be uniform or may vary as required in areas of the surface(s) which need to be attached or detached.

23. A method of attaching or bonding two or more surfaces together comprising:

(i) applying an adhesive composition according to claim 1 to one or more of the contact surfaces of each or all items which is to be bonded together; and

(ii) supplying sufficient thermal radiation and/ or thermal conduction to the composition via contact with one or more of the contact surfaces of each or all items which is to be bonded together so as to cause a proportion of the thermoexpandable microspheres to expand and optionally to further release a curing agent into the composition during the bonding process.

24. A method according to claim 23 further including any one or more of the features recited in claims 2 to 19.

25. A method of detaching or debonding two or more surfaces that have been bonded together comprising, supplying sufficient thermal radiation and/ or thermal conduction to a surface having coated thereon or attached thereto the composition according to claim 1, the thermal energy being supplied to one or more of the contact surfaces of each item which are to be detached/separated so as to cause the thermoexpandable microspheres to increase the volume.

26. A method according to claim 25 further including any one or more of the features recited in claims 2 to 24.

27. An apparatus for attaching or detaching two or more surfaces that have been bonded together comprising an IR emitting device comprising at least one bulb, at least one lens and at least one reflecting mirror mutually arranged so that heat is directed or focused only at an adhesive interface or a path where the thermoexpandable microspheres are purposely present.

28. An apparatus according to claim 27 capable of emitting IR radiation in the range of about 800-1400 nm to 2000-6000 nm.

29. An apparatus according to either claim 27 or 28 that is automated and operably linked to a computer programme providing information to device sensors of an adhesive bonding path.

30. An apparatus according to any one of claims 27 to 29 mounted on a mobile unit so that it is free to follow a predefined adhesive bonding path.

31. An apparatus according to any one of claims 27 to 30 capable of concentrating an IR beam at certain partial points of the surface which it is desired to bond or de-bond in different steps at command.

32. An apparatus according to any one of claims 27 to 31 that is pre-programmed to follow a specific bonding path in direction, width and breadth.

FIG 1 A

FIG 1. B

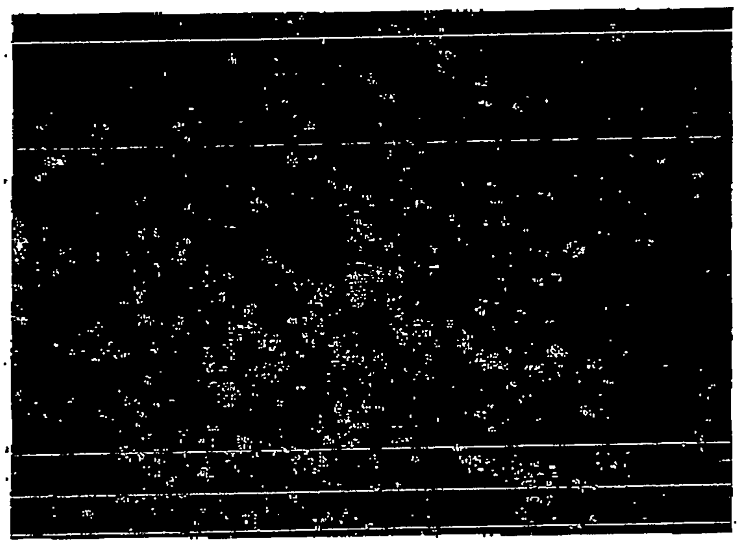

FIG. 1 C

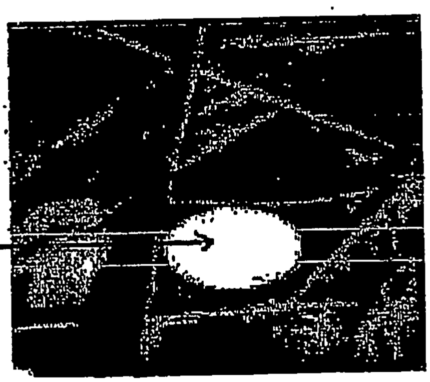

FIG. 1D

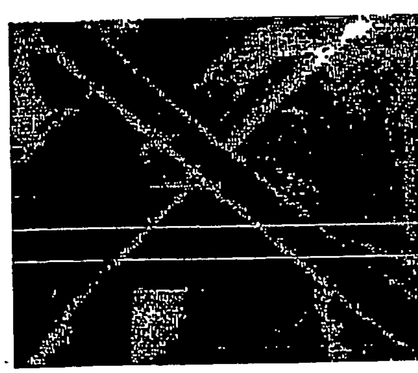

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FIG 2

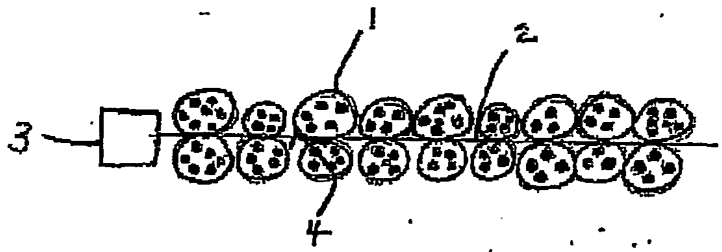
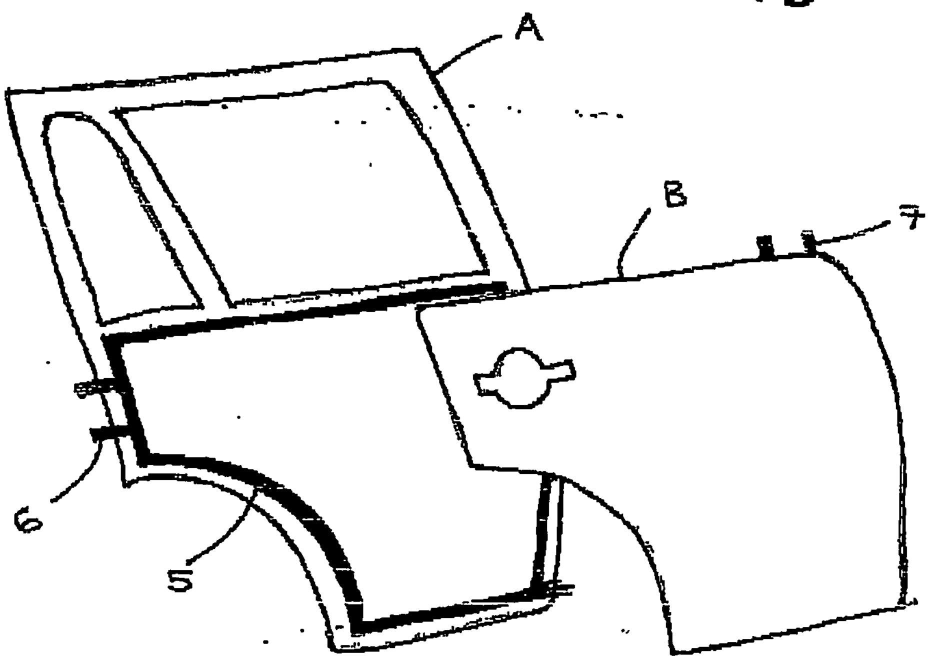


FIG. 3



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